

# Isolated TR: when and how should we intervene?

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## Tricuspid regurgitation is a public health crisis

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- **Isolated** tricuspid regurgitation =
  - TR without left sided valve disease,
  - without LV dysfunction
  - without pulmonary hypertension

# TR unrecognized and untreated disease ?

- US prevalence of 1.6 million patients with prevalent moderate severe TR vs. the 8 to 10,000 tricuspid surgeries performed yearly. Considering the incident cases estimated in the nation no more than 4 to 5% of incident cases are ever operated.

- In the small subset of flail tricuspid leaflets, around 50% of cases underwent tricuspid surgery.

*Messika-Zeitoun D, J Thorac Cardiovasc Surg 2004;128: 296-302.*

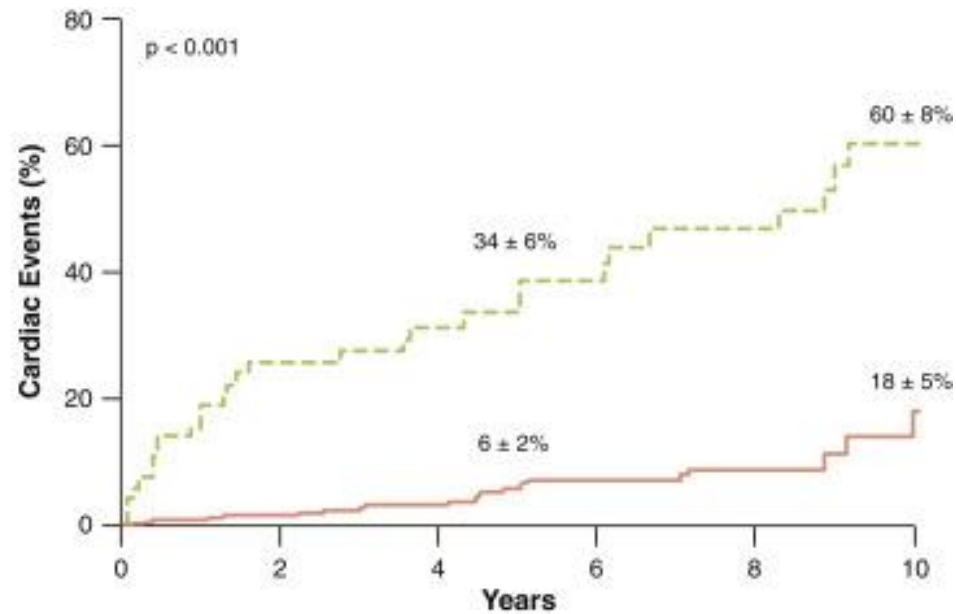
- In the context of isolated TR, despite the absence of LV dysfunction, left-sided valve disease or PH, only 8% ever get tricuspid surgery performed.<sup>28</sup>

*Topilsky Y, J Am Coll Cardiol Img 2014;7:1185-1194..*

# Clinical Outcome of Isolated Tricuspid Regurgitation



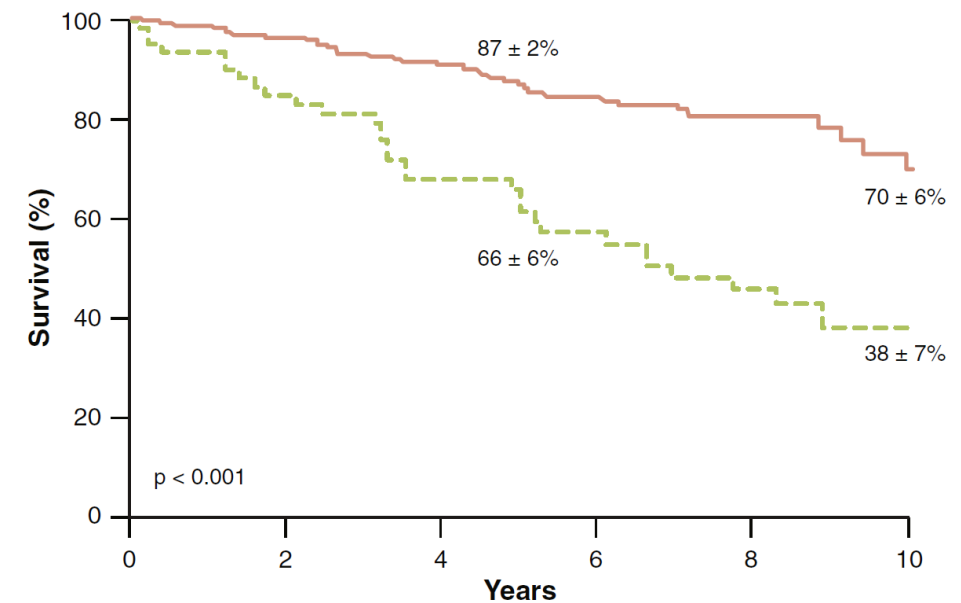
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Maurice Enriquez-Sarano, MD†



## Number at Risk

	0	2	4	6	8	10
<b>Total</b>	353	294	242	183	65	29
<b>ERO &lt; 40</b>	285	252	209	160	46	23
<b>ERO ≥ 40</b>	68	42	33	23	19	6

— ERO ≥ 40 mm<sup>2</sup> — ERO < 40 mm<sup>2</sup>



## Number at Risk

	0	2	4	6	8	10
<b>Total</b>	353	308	252	194	70	31
<b>ERO &lt; 40</b>	285	253	210	163	46	23
<b>ERO ≥ 40</b>	68	55	42	31	24	8

— ERO ≥ 40 mm<sup>2</sup> — ERO < 40 mm<sup>2</sup>

# Outcomes of isolated tricuspid valve replacement: a systematic review and meta-analysis of 5,316 patients from 35 studies

Andrea Scotti<sup>1,2</sup>, MD; Matteo Sturla<sup>1</sup>, MD; Juan F. Granada<sup>1,2</sup>, MD; Susheel K. Kodali<sup>3</sup>, MD; Augustin Coisne<sup>1,2</sup>, MD, PhD; Antonio Mangieri<sup>4</sup>, MD; Cosmo Godino<sup>5</sup>, MD; Edwin Ho<sup>1</sup>, MD; Ythan Goldberg<sup>1</sup>, MD; Mei Chau<sup>1</sup>, MD; Ulrich P. Jorde<sup>1</sup>, MD; Mario J. Garcia<sup>1</sup>, MD; Francesco Maisano<sup>5</sup>, MD; Vinayak N. Bapat<sup>6</sup>, MD; Gorav Ailawadi<sup>7</sup>, MD, MBA; Azeem Latib<sup>1\*</sup>, MD

Outcome	Proportion/incidence rate % (95% CI)	I <sup>2</sup> % ( $\chi^2$ <i>p</i> -value)	N. of studies
<b>Early outcomes</b>			
Bleeding	12 (8-17)	83 (<0.01)	17
Acute kidney injury	15 (9-24)	89 (<0.01)	11
Renal replacement therapy	7 (3-15)	63 (0.01)	7
Pacemaker implantation	10 (6-16)	75 (<0.01)	13
Respiratory complication	15 (12-20)	0 (0.56)	7
Stroke	2 (1-4)	74 (<0.01)	9
Wound infection	3 (2-6)	81 (<0.01)	10

# Outcomes of isolated tricuspid valve replacement: a systematic review and meta-analysis of 5,316 patients from 35 studies

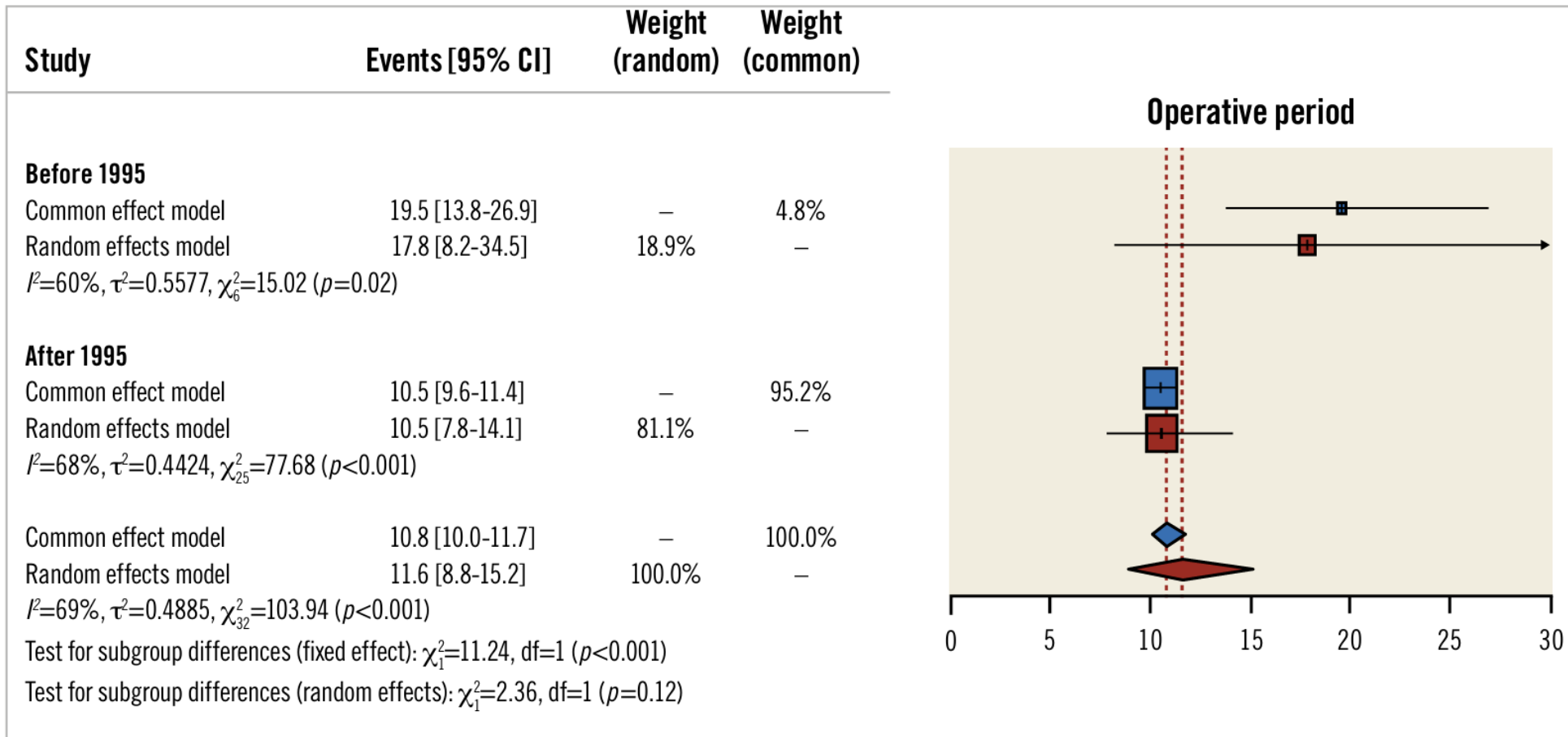
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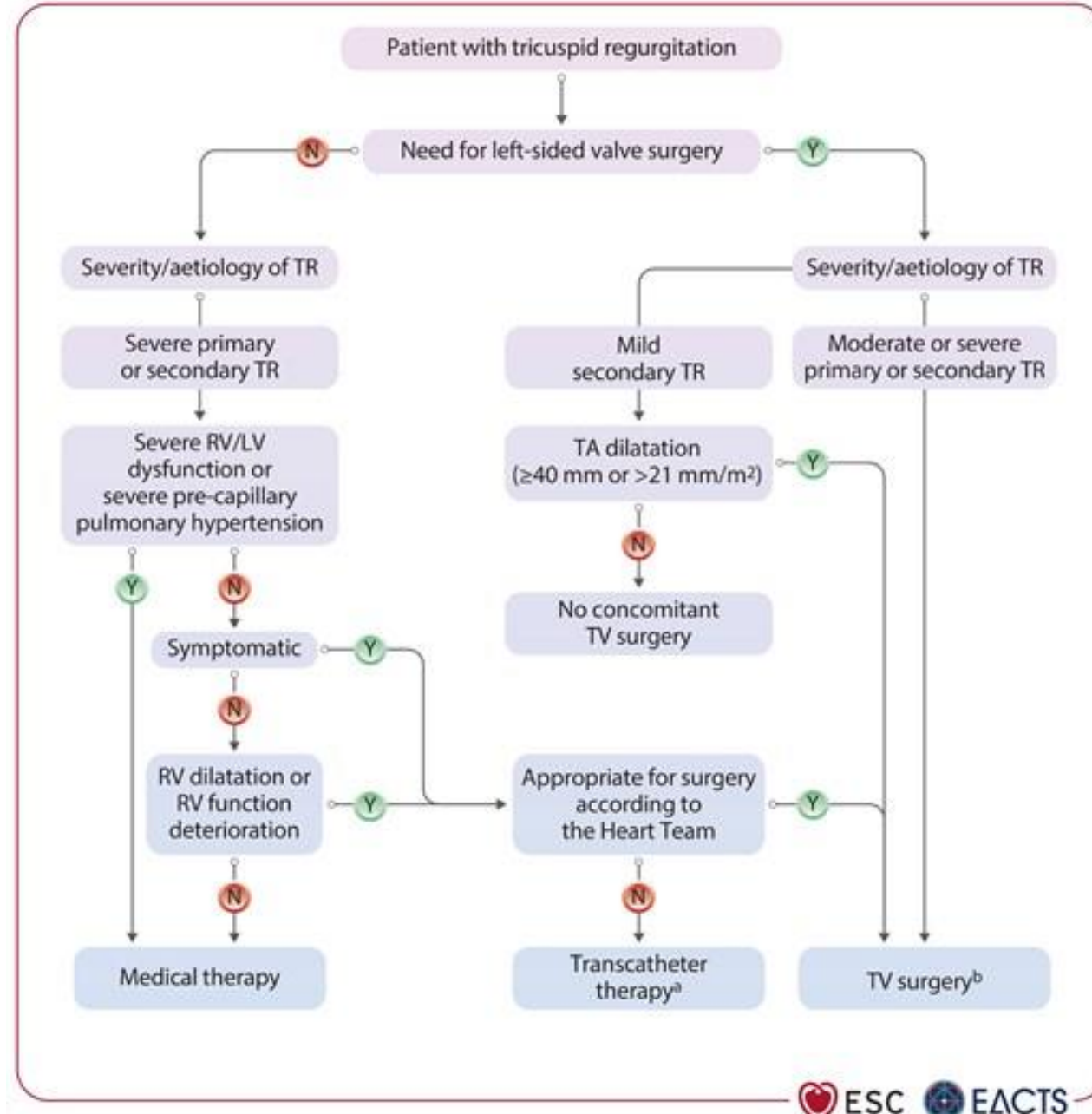
Outcome	Proportion/incidence rate % (95% CI)	I <sup>2</sup> % (X <sup>2</sup> p-value)	N. of studies
<b>Late outcomes</b>			
Late mortality*	6 (4-9)	96 (<0.01)	23
Reintervention*	2 (1-3)	64 (<0.01)	15
Structural valve deterioration*	3 (1-6)	82 (<0.01)	9
Valve thrombosis*	1 (0-2)	49 (0.07)	8
Recurrence of TR ≥2*	5 (2-13)	85 (<0.01)	4
<b>Bioprostheses</b>			
Late mortality*	6 (2-13)	97 (<0.01)	8
Reintervention*	1 (1-3)	77 (<0.01)	5
Structural valve deterioration*	3 (1-9)	91 (<0.01)	4
Valve thrombosis*	0 (0-1)	68 (0.04)	3
Recurrence of TR ≥2*	8 (5-13)	33 (0.22)	3

\*per 100 person-years. CI: confidence interval; TR: tricuspid regurgitation

# Outcomes of isolated tricuspid valve replacement: a systematic review and meta-analysis of 5,316 patients from 35 studies

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Patients with severe tricuspid regurgitation without left-sided valvular heart disease requiring surgery		
TV surgery <sup>c</sup> is recommended in symptomatic patients with severe primary TR without severe RV dysfunction or severe PH.	<b>I</b>	<b>C</b>
TV surgery <sup>c</sup> should be considered in asymptomatic patients with severe primary TR who have RV dilatation/RV function deterioration, but without severe LV/RV dysfunction or severe PH.	<b>IIa</b>	<b>C</b>
TV surgery <sup>c</sup> should be considered in patients with severe secondary TR who are symptomatic or have RV dilatation/RV function deterioration, but without severe LV/RV dysfunction or PH. <sup>685,720,745–747</sup>	<b>IIa</b>	<b>B</b>
Transcatheter TV treatment should be considered to improve quality of life and RV remodelling in high-risk patients with symptomatic severe TR despite optimal medical therapy in the absence of severe RV dysfunction or pre-capillary PH. <sup>713,733,735,738,748–751</sup>	<b>IIa</b>	<b>A</b>

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LV, left ventricle/left ventricular; PH, pulmonary hypertension; RV, right ventricle/right ventricular; TR, tricuspid regurgitation; TV, tricuspid valve.

<sup>a</sup>Class of recommendation.

<sup>b</sup>Level of evidence.

<sup>c</sup>Valve repair whenever possible.

# Determinants of clinical outcomes of surgery for isolated severe tricuspid regurgitation






Sung Jun Park <sup>1</sup>, Jin Kyung Oh <sup>2</sup>, Seon-Ok Kim,<sup>3</sup> Seung-Ah Lee,<sup>4</sup> Ho Jin Kim,<sup>1</sup> Sahmin Lee,<sup>4</sup> Sung Ho Jung,<sup>1</sup> Jong-Min Song,<sup>4</sup> Suk Jung Choo,<sup>1</sup> Duk-Hyun Kang,<sup>4</sup> Cheol Hyun Chung,<sup>1</sup> Jae-Kwan Song <sup>4</sup>, Jae Won Lee <sup>1</sup>, Dae-Hee Kim <sup>4</sup>, Joon Bum Kim<sup>1</sup>

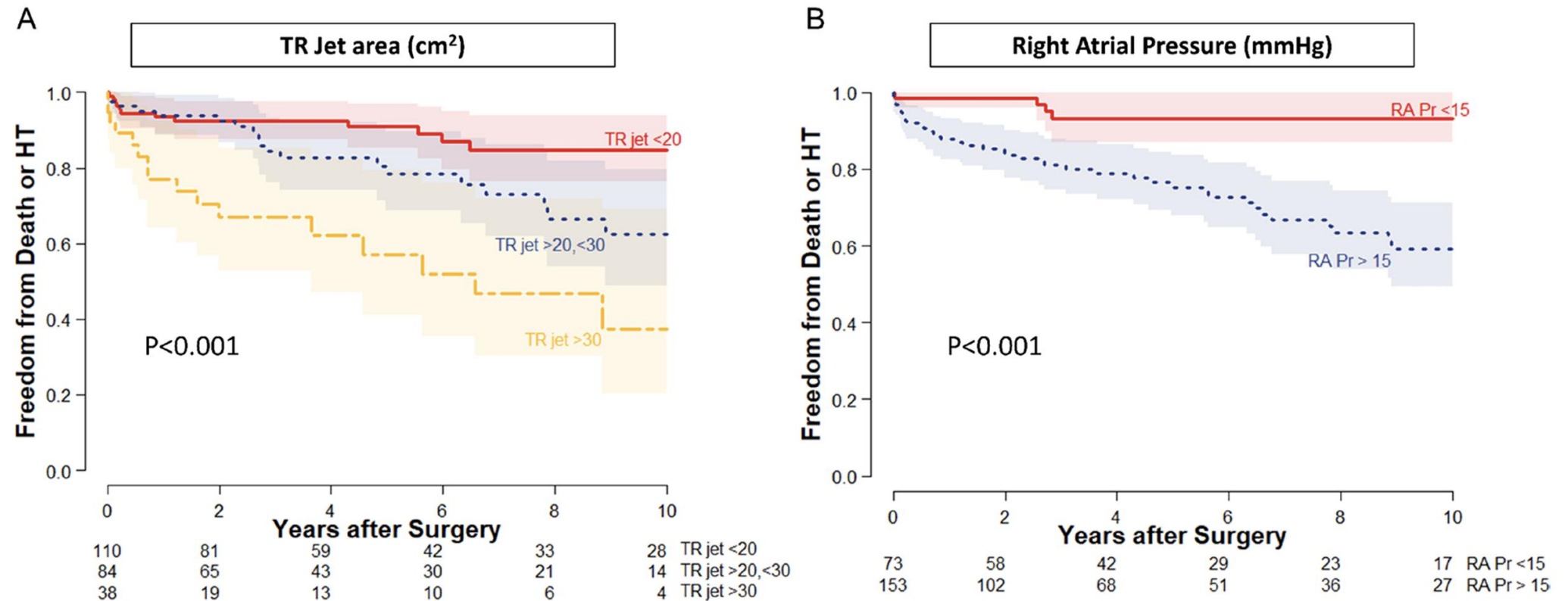
**Table 3** Univariable and multivariable analyses for the primary outcome

	Univariable			Multivariable		
	HR	95% CI	P value	HR	95% CI	P value
Age	1.05	1.03 to 1.08	<0.001	1.05	1.02 to 1.08	0.001
NYHA class 3–4	1.79	1.06 to 3.04	0.031			
Coronary artery disease	2.16	1.08 to 4.33	0.029			
Haemoglobin	0.75	0.67 to 0.84	<0.001	0.83	0.73 to 0.94	0.003
Platelet count	0.99	0.986 to 0.996	<0.001			
Estimated glomerular filtration rate	0.98	0.97 to 0.99	0.002			
Total bilirubin	1.58	1.02 to 2.33	0.022	1.50	1.02–2.20	0.040
Albumin	0.49	0.32 to 0.76	0.001			
Tricuspid regurgitant jet area	1.05	1.03 to 1.08	<0.001	1.03	1.01 to 1.06	0.005
Tricuspid annular diameter	1.06	1.01 to 1.10	0.014			
Right atrial pressure	1.23	1.09 to 1.39	<0.001	1.14	1.02 to 1.28	0.022
Fractional area change	0.95	0.92 to 0.99	0.015			

NYHA, New York Heart Association.

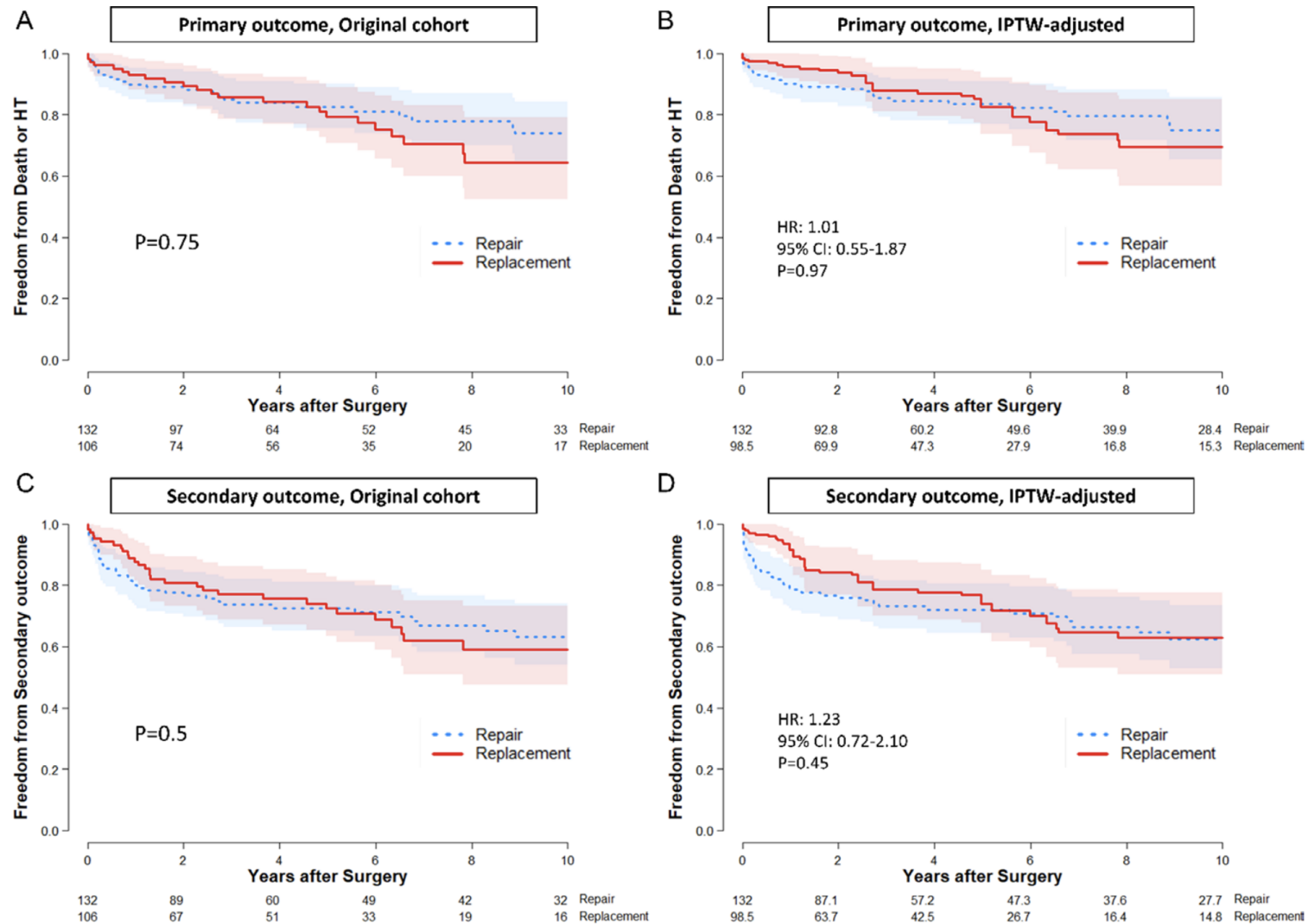
# Determinants of clinical outcomes of surgery for isolated severe tricuspid regurgitation

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**Figure 2** The primary outcomes stratified by (A) tricuspid regurgitant (TR) jet area and (B) right atrial (RA) pressure.

# Determinants of clinical outcomes of surgery for isolated severe tricuspid regurgitation



**Figure 3** Repair versus replacement. (A) The primary outcome in the original cohort and (B) the IPTW-adjusted cohort. (C) The secondary outcome in the original cohort and (D) the IPTW-adjusted cohort. IPTW, inverse probability of treatment weighting.

- Risk stratification model

**TRI-SCORE: a new risk score for in-hospital mortality prediction after isolated tricuspid valve surgery**

- Consecutive adult patients who underwent ITVS for severe non-congenital TR at 12 French centres between 2007 and 2017
- 466 patients (60 ± 16 years, 49% female, functional TR in 49%).
- Inhospital mortality rate was 10%.
- Scoring system to predict in-hospital mortality using multivariable logistic regression and bootstrapping

# Isolated tricuspid reg: timing for intervention ?

## TRI-SCORE: a new risk score for in-hospital mortality prediction after isolated tricuspid valve surgery

**Risk factors and scoring system  
for in-hospital mortality after isolated tricuspid valve surgery**

Risk factors (final model from multivariate analysis)	Scoring
Age $\geq$ 70 years	1
NYHA functional class III-IV	1
Right-sided heart failure signs	2
Daily dose of furosemide $\geq$ 125mg	2
Glomerular filtration rate $<$ 30 ml/min	2
Elevated total bilirubin	2
Left ventricular ejection fraction $<$ 60%	1
Moderate/severe right ventricular dysfunction	1
<b>Total</b>	<b>12</b>

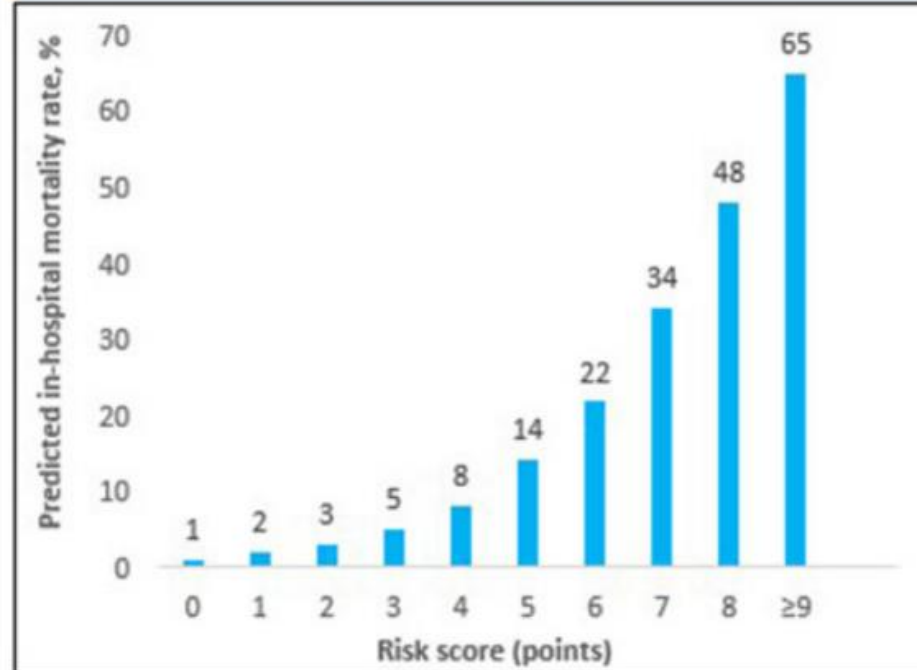
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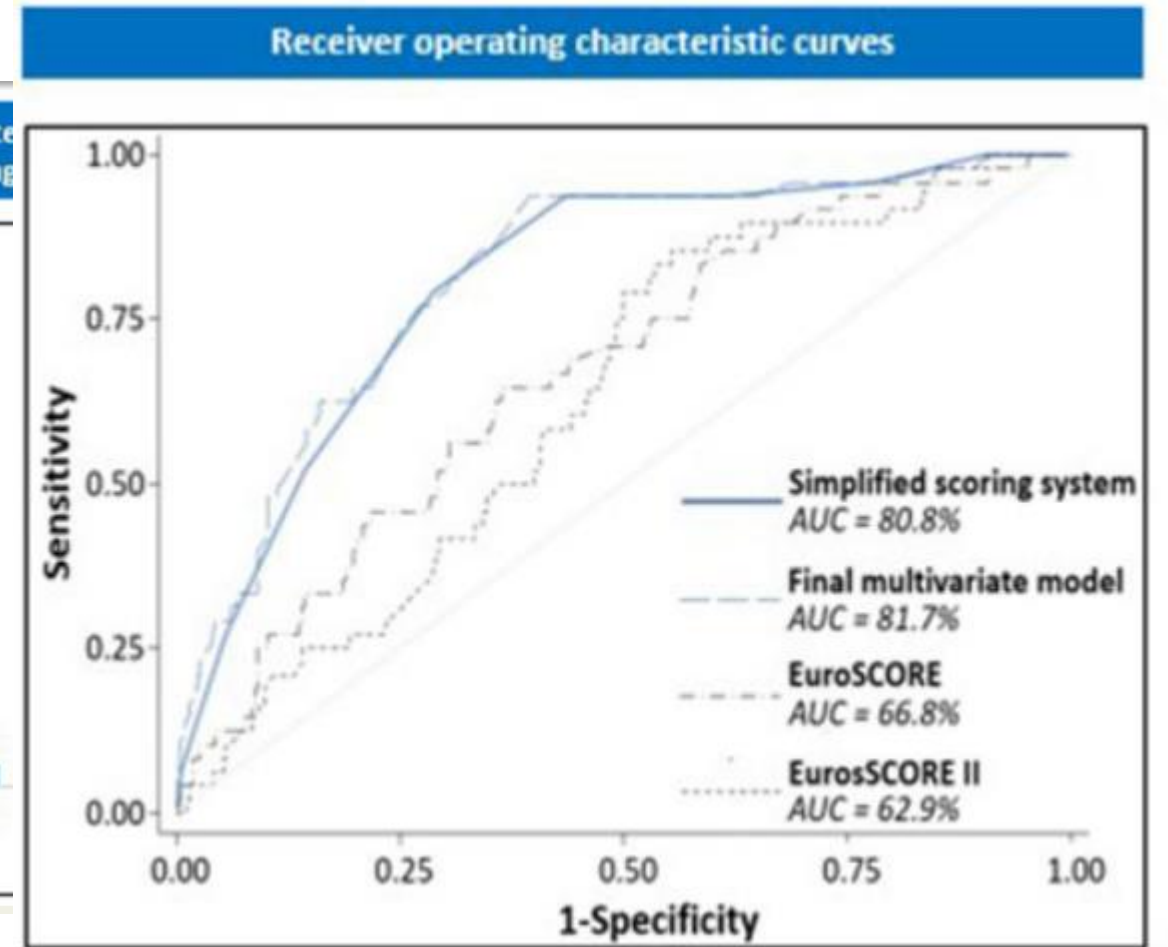
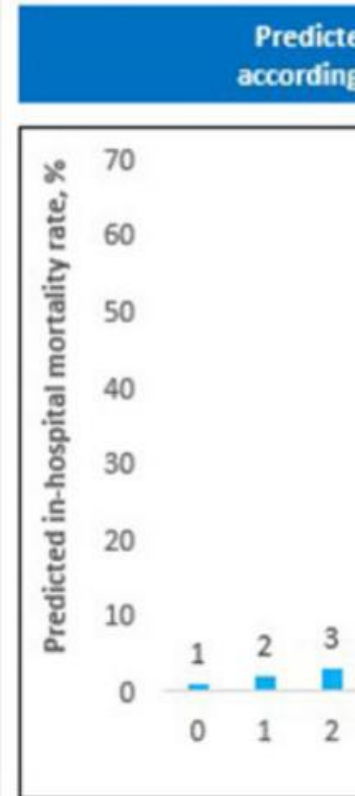
Predicted in-hospital mortality rate  
according to the final risk score model



# Isolated tricuspid reg: timing for intervention ?

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# Benefit of isolated surgical valve repair or replacement for functional tricuspid regurgitation and long-term outcomes stratified by the TRI-SCORE

Julien Dreyfus <sup>1\*</sup>, Fernando Juarez-Casso<sup>2</sup>, Alessandra Sala<sup>3</sup>,

## TRIGISTRY: multicenter registry



33 centers



10 countries



1768 patients with severe isolated functional tricuspid regurgitation

Comparison of 10-year survival rates between treatment modalities according to the TRI-SCORE category (low, intermediate and high)



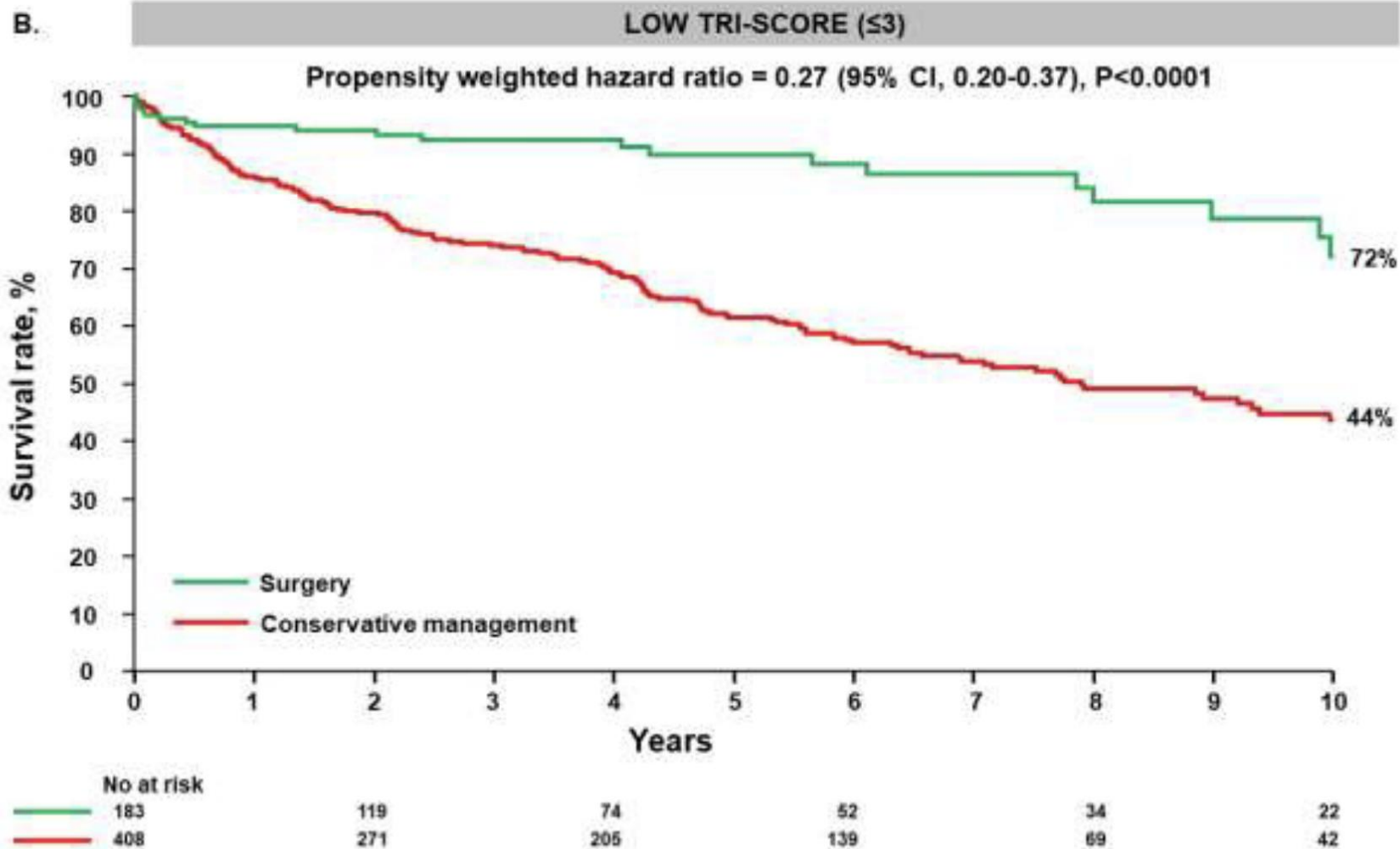
1217 conservatively managed



551 isolated tricuspid valve surgery

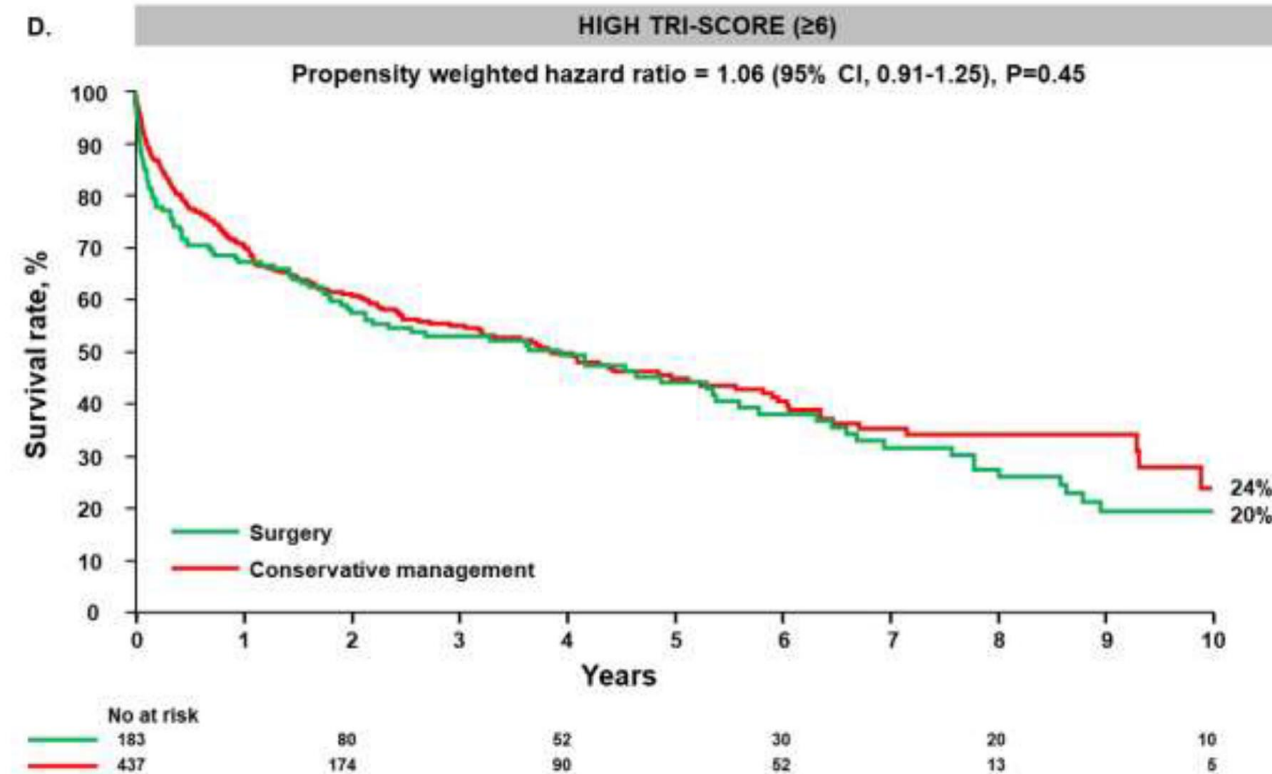
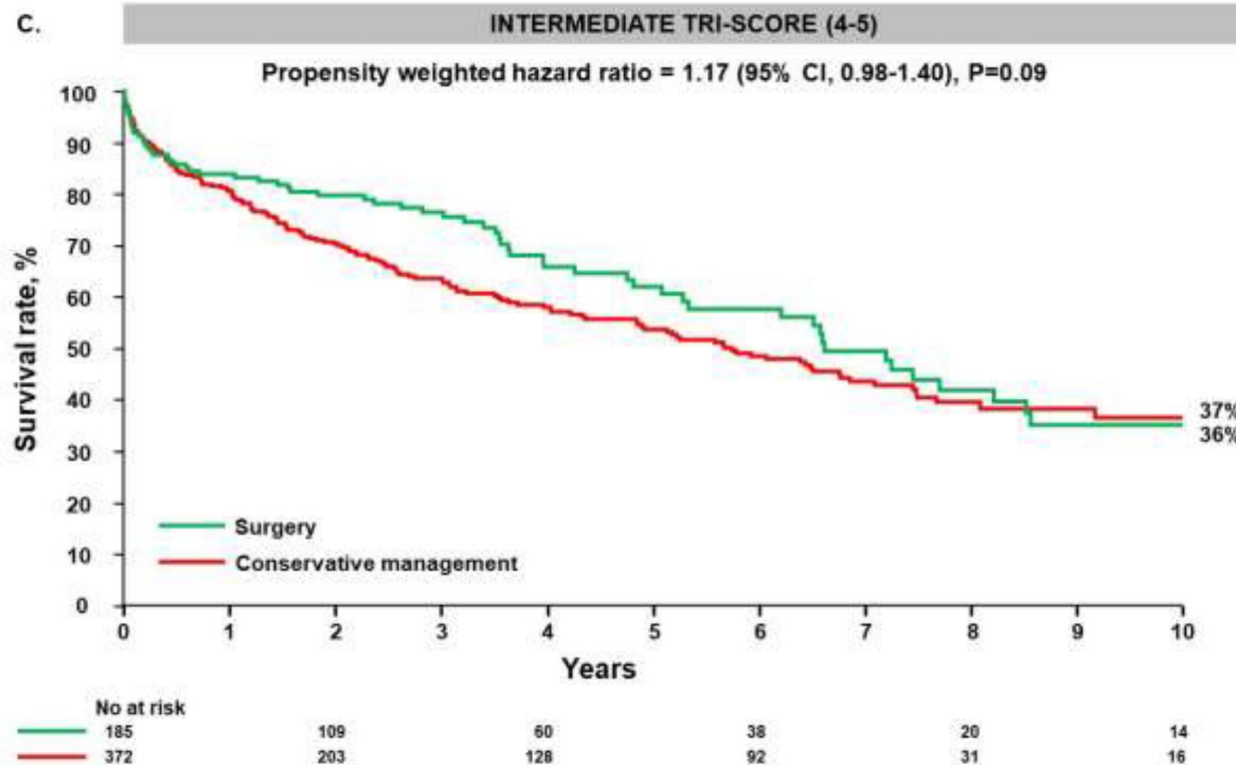
200 repair

351 replacement

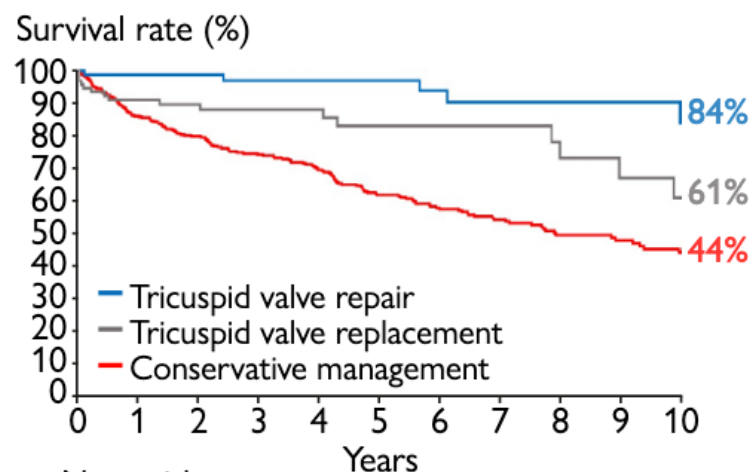


# Benefit of isolated surgical valve repair or replacement for functional tricuspid regurgitation and long-term outcomes stratified by the TRI-SCORE

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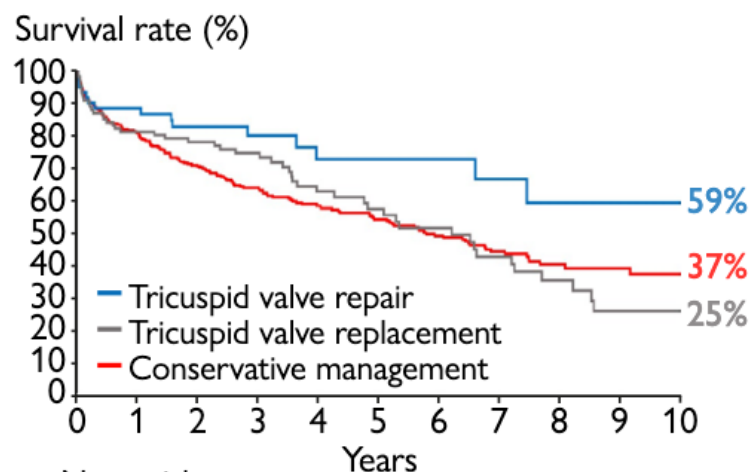
## Low TRI-SCORE ( $\leq 3$ )



No at risk

83	62	38	27	19	13
100	57	36	24	15	9
408	271	205	139	69	42

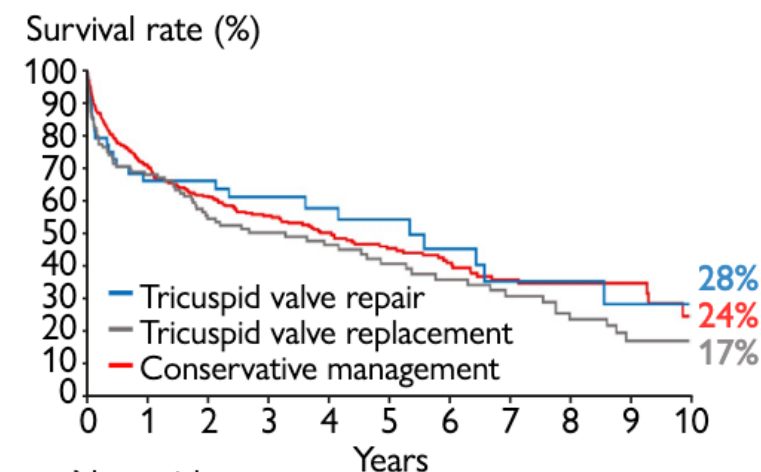
## Intermediate TRI-SCORE (4–5)



No at risk

62	38	20	14	8	6
123	71	40	24	12	8
372	203	128	92	31	16

## High TRI-SCORE ( $\geq 6$ )



No at risk

55	27	17	9	6	4
128	53	35	21	14	6
437	174	90	52	13	5

## Propensity weighted hazard ratio

### Low TRI-SCORE ( $\leq 3$ )

### Intermediate TRI-SCORE (4–5)

### High TRI-SCORE ( $\geq 6$ )

Repair vs conservative management	0.11 (95% CI, 0.06–0.19), $P < 0.0001$	0.49 (95% CI, 0.35–0.68), $P < 0.0001$	0.86 (95% CI, 0.68–1.08), $P = 0.20$
Replacement vs conservative management	0.65 (95% CI, 0.47–0.90), $P = 0.009$	1.43 (95% CI, 1.18–1.72), $P = 0.0002$	1.58 (95% CI, 1.35–1.86), $P < 0.0001$
Repair vs replacement	0.17 (95% CI, 0.09–0.32), $P < 0.0001$	0.34 (95% CI, 0.24–0.48), $P < 0.0001$	0.54 (95% CI, 0.43–0.68), $P < 0.0001$

# Outcomes of Isolated Tricuspid Valve Surgery: A Society of Thoracic Surgeons Analysis and Risk Model

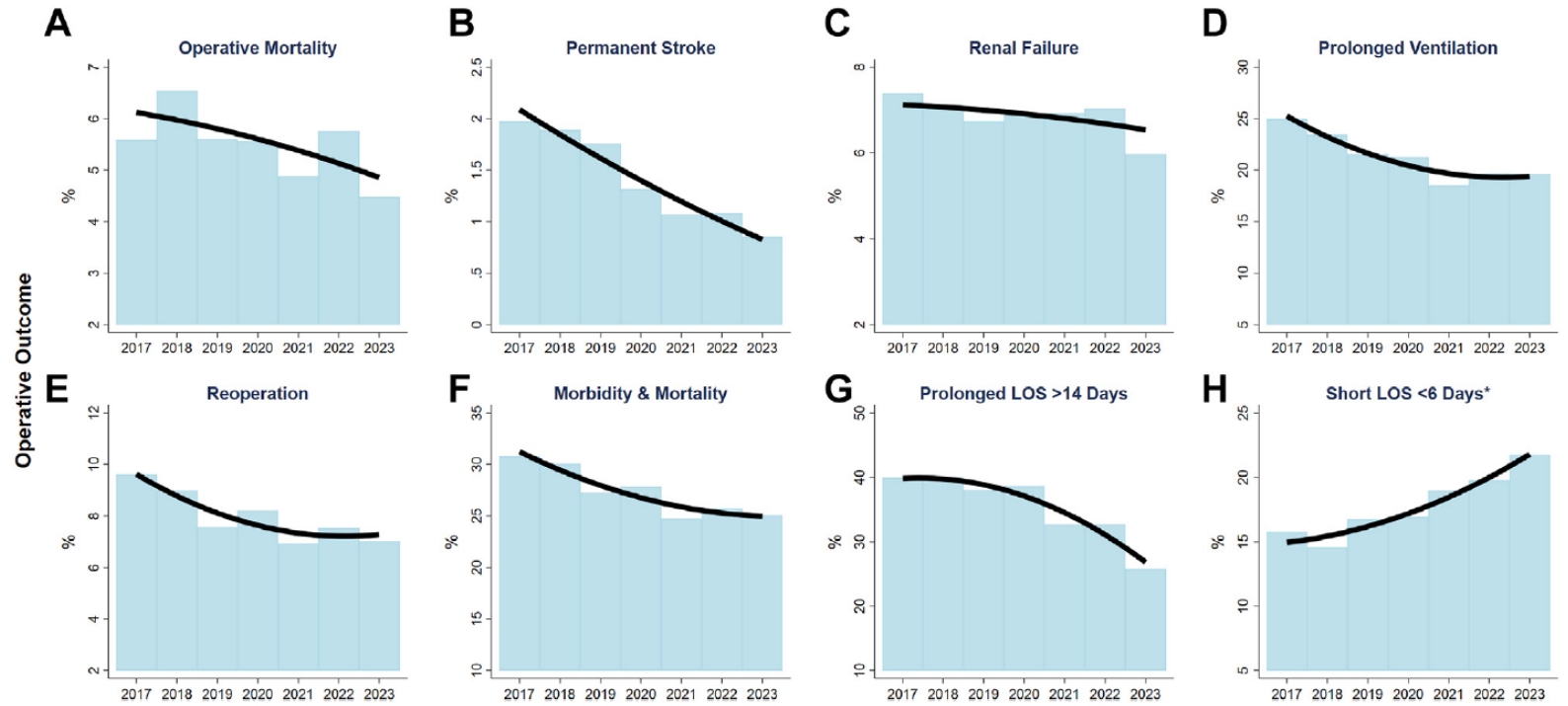


Vinod H. Thourani, MD,<sup>1</sup> Levi Bonnell, PhD,<sup>2</sup> Moritz C. Wyler von Ballmoos, MD, PhD,<sup>3</sup> J. Hunter Mehaffey, MD,<sup>4</sup> Michael Bowdish, MD,<sup>5</sup> Paul Kurlansky, MD,<sup>6</sup> Jeffrey P. Jacobs, MD,<sup>7</sup> Sean O'Brien, PhD,<sup>8</sup> David M. Shahian, MD,<sup>9</sup> and Vinay Badhwar, MD<sup>4</sup>

**TABLE 2 Observed Outcomes by Procedure Type in Isolated Tricuspid Valve Surgery Study Group**

Outcome	TVRr N = 13,587	N (%)	
		TVr n = 5583	TVR n = 8004
Operative mortality	760 (5.6)	304 (5.4)	456 (5.7)
Stroke	197 (1.4)	116 (2.1)	81 (1.0)
Renal failure	928 (6.8)	400 (7.2)	528 (6.6)
Prolonged ventilation	2884 (21.2)	1299 (23.3)	1585 (19.8)
Reoperation	1083 (8.0)	484 (8.7)	599 (7.5)
Morbidity and mortality	3717 (27.4)	1576 (28.2)	2141 (26.7)
DSWI <sup>a</sup>	79 (0.6)	30 (0.5)	49 (0.6)
Prolonged LOS >14 d	4908 (36.1)	1978 (35.4)	2930 (36.6)
Short LOS <6 d	2368 (17.4)	1223 (21.9)	1145 (14.3)

<sup>a</sup>Risk models not created because of low event counts. DSWI, deep sternal wound infection; LOS, length of stay; TVr, tricuspid valve repair; TVR, tricuspid valve replacement; TVRr, tricuspid valve replacement or repair.



**FIGURE 2** Observed outcome over the study period for each of the 8 outcomes: (A) operative mortality, (B) permanent stroke, (C) renal failure, (D) prolonged ventilation, (E) reoperation, (F) morbidity and mortality, (G) prolonged length of stay (LOS) >14 days, and (H) short LOS <6 days.

- STS tricuspid score



The Society  
of Thoracic  
Surgeons

## Risk Calculator - Isolated Tricuspid Valve Surgery

STS - Adult Cardiac Surgery Database

Answer All Questions for Accurate Estimates

Tricuspid Surgery

☒ Replace
 ☐ Repair

☐ Concomitant ASD/PFO

Surgical Priority

Surgery Incidence

☐ Previous CABG

Previous Surgical Valve (Click HERE to select)

None

Previous Other Cardiac Interventions

Select all that apply

Previous PCI

Select

Previous Transcatheter Valve Intervention

Select all that apply

Demographics

Sex

Age

Height

Weight

Race/Ethnicity

Payor/Insurance

Laboratory Values

Creatinine

Hematocrit

WBC Count

Platelet Count

Total Albumin

Total Bilirubin

INR

Risk Factors/Comorbidities

Diabetes

☐ Family Hx of CAD
 ☐ Hypertension
 ☐ Liver Disease
 ☐ Mediastinal Radiation
 ☐ Unresponsive State

☐ Dialysis
 ☐ Cancer ≤ 5 yrs
 ☐ Syncope
 ☐ Immunocompromised

Endocarditis

Illicit Drug Use

Alcohol Use

Tobacco Use

Pulmonary

Chronic Lung Disease

☐ Recent Pneumonia
 ☐ Sleep Apnea
 ☐ Home O<sub>2</sub>

Vascular

☐ Peripheral Artery Disease
 ☐ Prior Carotid Surgery
 ☐ Right Carotid Stenosis ≥ 80%
 ☐ Left Carotid Stenosis ≥ 80%

Cerebrovasc. Disease

Cardiac Status

Heart Failure

NYHA Classification

PreOp Mech Circ Support

Ejection Fraction (%)

☐ Cardiogenic Shock
 ☐ Resuscitation ≤ 1hr

Coronary Artery Disease

Prim. Coronary Symptom

Myocardial Infarction

No. of Diseased Vessels

Valve Disease

☐ Aortic Stenosis
 ☐ Mitral Stenosis
 ☐ Tricuspid Stenosis
 ☐ Pulmonic Stenosis

☐ Aortic Root Abscess

Aortic Regurgitation

Mitral Regurgitation

Tricuspid Regurgitation

Pulmonic Regurgitation

Arrhythmia

Atrial Fibrillation

Atrial Flutter

V. Tach / V. Fib

Sick Sinus Syn.

2<sup>nd</sup> Degree Block

3<sup>rd</sup> Degree Block

Preoperative Medications

☐ ACE Inhibitors/ARBs ≤48 hrs
 ☐ GP IIb/IIIa Inhibitors ≤24 hrs
 ☐ ADP Inhibitors ≤5 days
 ☐ Inotropes ≤48 hrs
 ☐ Steroids ≤24 hrs
 ☐ Coumadin ≤5 days

Calculations

BMI (kg/m<sup>2</sup>)

BSA (m<sup>2</sup>)

MELD Score

Clinical Summary

About

### Simulated Patient Summary

Procedure Type: Isolated TV Replacement

PERIOPERATIVE OUTCOME	ESTIMATE %
Operative Mortality	0.386%
Morbidity & Mortality	6.32%
Stroke	0.089%
Renal Failure	0.744%
Reoperation	3.97%
Prolonged Ventilation	3.98%
Deep Sternal Wound Infection	NA
Long Hospital Stay (>14 days)	7.06%
Short Hospital Stay (<6 days)*	61.1%

\*higher values reflect a better outcome

Copy

### Clinical Summary

Planned Surgery: Isolated TV Replacement

Demographics: 19 year old male

PDF(Patient Summary)

Copy

This application was developed and implemented at the STS Research and Analytic Center; contact at [research@sts.org](mailto:research@sts.org)  
(App Version: 1.0.2; Last Updated: January 9, 2025)

Full Screenshot Reset

Ann Thorac Surg 2024;118:873-881. doi: <https://doi.org/10.1016/j.athoracsur.2024.04.014>

Membre du réseau  
Lid van het netwerk

Huni

- STS tricuspid score



The Society  
of Thoracic  
Surgeons

## Risk Calculator - Isolated Tricuspid Valve Surgery

STS - Adult Cardiac Surgery Database

Answer All Questions for Accurate Estimates

### Tricuspid Surgery

☒ Replace
 ☐ Repair

☐ Concomitant ASD/PFO

Surgical Priority 1

Surgery Incidence 1

☐ Previous CABG

Previous Surgical Valve (Click HERE to select) 1

Previous Other Cardiac Interventions 1

Previous PCI 1

Previous Transcatheter Valve Intervention 1

### Demographics

Sex 1

Age 1  Years

Height 1  cm

Weight 1  kg

Race/Ethnicity 1

Payor/Insurance 1

### Laboratory Values

Creatinine 1  mg/dL

Hematocrit 1  %

WBC Count 1  10<sup>3</sup>/μL

Platelet Count 1  cells/μL

Total Albumin 1  g/dL

Total Bilirubin 1  mg/dL

INR 1  Ratio

### Risk Factors/Comorbidities

Diabetes 1

☐ Family Hx of CAD  
☐ Hypertension  
☐ Liver Disease  
☐ Mediastinal Radiation  
☐ Unresponsive State

☐ Dialysis  
☐ Cancer ≤ 5 yrs  
☐ Syncope  
☐ Immunocompromised

Endocarditis 1

Illicit Drug Use 1

Alcohol Use 1

Tobacco Use 1

### Pulmonary

Chronic Lung Disease 1

☐ Recent Pneumonia  
☐ Sleep Apnea  
☐ Home O<sub>2</sub>

### Vascular

☐ Peripheral Artery Disease  
☐ Prior Carotid Surgery  
☐ Right Carotid Stenosis ≥ 80%  
☐ Left Carotid Stenosis ≥ 80%

Cerebrovasc. Disease 1

### Cardiac Status

Heart Failure 1

NYHA Classification 1

PreOp Mech Circ Support 1

Ejection Fraction (%) 1

☐ Cardiogenic Shock  
☐ Resuscitation ≤ 1hr

### Coronary Artery Disease

Prim. Coronary Symptom 1

Myocardial Infarction 1

No. of Diseased Vessels 1

### Valve Disease

☐ Aortic Stenosis  
☐ Mitral Stenosis  
☐ Tricuspid Stenosis  
☐ Pulmonic Stenosis

☐ Aortic Root Abscess

Aortic Regurgitation 1

Mitral Regurgitation 1

Tricuspid Regurgitation 1

Pulmonic Regurgitation 1

### Arrhythmia

Atrial Fibrillation 1

Atrial Flutter 1

V. Tach / V. Fib 1

Sick Sinus Syn. 1

2<sup>nd</sup> Degree Block 1

3<sup>rd</sup> Degree Block 1

### Preoperative Medications

☐ ACE Inhibitors/ARBs ≤48 hrs  
☐ GP IIb/IIIa Inhibitors ≤24 hrs  
☐ ADP Inhibitors ≤5 days  
☐ Inotropes ≤48 hrs  
☐ Steroids ≤24 hrs  
☐ Coumadin ≤5 days

### Calculations

BMI (kg/m<sup>2</sup>) 1

BSA (m<sup>2</sup>) 1

MELD Score 1

This application was developed and implemented at the STS Research and Analytic Center; contact at [research@sts.org](mailto:research@sts.org)  
(App Version: 1.0.2; Last Updated: January 9, 2025)

Full Screenshot Reset

Clinical Summary

About

### Simulated Patient Summary

Procedure Type: Isolated TV Replacement

PERIOPERATIVE OUTCOME	ESTIMATE %
Operative Mortality	0.386%
Morbidity & Mortality	6.32%
Stroke	0.089%
Renal Failure	0.744%
Reoperation	3.97%
Prolonged Ventilation	3.98%
Deep Sternal Wound Infection	NA
Long Hospital Stay (>14 days)	7.06%
Short Hospital Stay (<6 days)*	61.1%

\*higher values reflect a better outcome

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### Clinical Summary

Planned Surgery: Isolated TV Replacement

Demographics: 19 year old male

PDF(Patient Summary)

Copy

## Conclusion

- More attention needed to diagnosing moderate and severe TR, with use of quantitative Doppler echocardiographic methods.
- Early consideration of tricuspid surgery before the occurrence of severe HF.
- Mandatory multidisciplinary Heart Team discussion.
- Risk analysis to optimize patients and procedure selection
- Need to test efficacy of therapies in appropriately designed randomized clinical trials.
  - Transcatheter vs Medical Therapy
  - Minimally invasive surgery vs Transcatheter therapy
  - Repair vs Replacement

Thank you



# Isolated tricuspid reg: timing for intervention ?

## TRI-SCORE and benefit of intervention in patients with severe tricuspid regurgitation

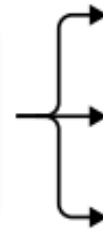


TRIGISTRY: multicenter registry (33 centers, 10 countries)



2413 patients with severe isolated functional tricuspid regurgitation

Comparison of survival rates at 2 years between different treatment modalities according to TRI-SCORE categories (low, intermediate and high)



1217 patients conservatively managed



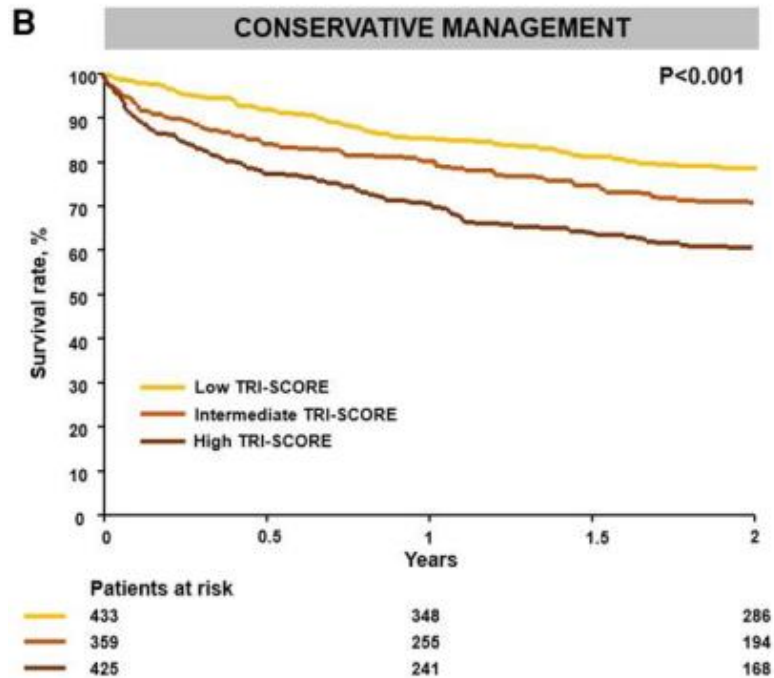
551 underwent isolated tricuspid valve surgery



645 underwent transcatheter valve repair

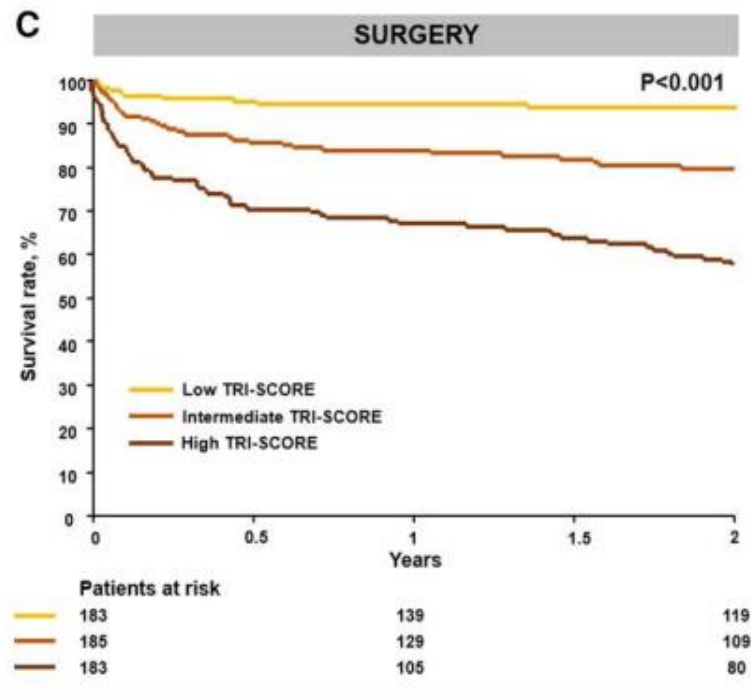
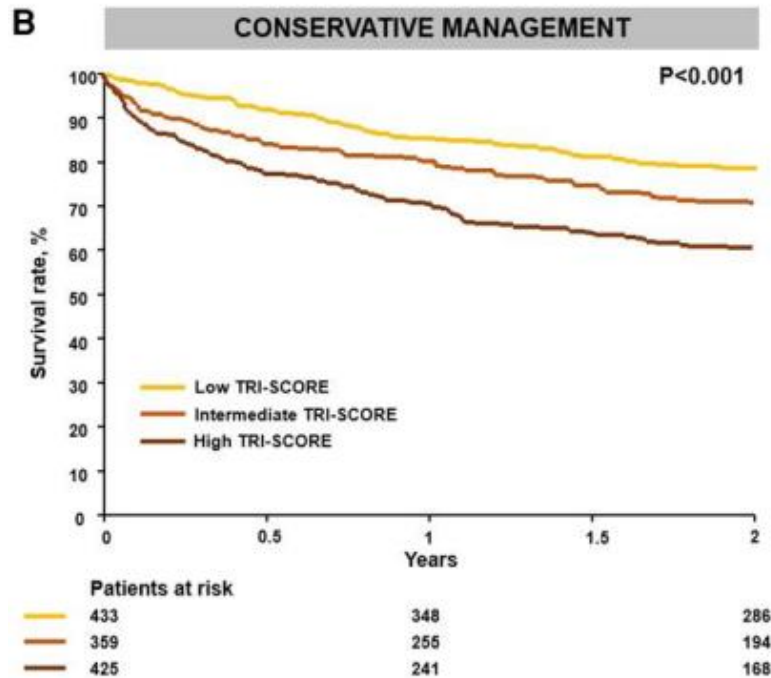
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